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PATENT ABSTRACTS OF JAPAN

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(71)Applicant : **NIPPON MEKTRON LTD**

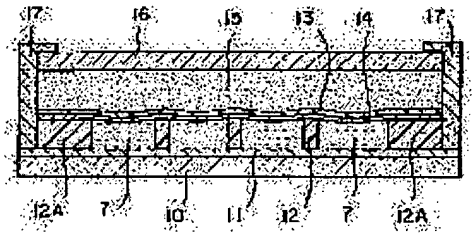
(72)Inventor : **OSHIRO TATSUHIKO**
TADAKUMA AKIRA
MORI TAKASHI
AKATSUKA TAKATOSHI
TOYAMA JIRO

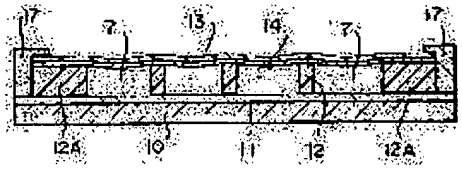
(54) ELECTROPHORESIS DISPLAY DEVICE AND ITS MANUFACTURE

(57)Abstract:

PURPOSE: To easily and securely inject a dispersion system into pores of porous spacers by bringing one electrode plate into contact with the porous spacers by arranging a pressure member or through the operation of a pressing force without the pressure member.

CONSTITUTION: One electrode plate is constituted flexible so as to contact the porous spacers 12, the other electrode plate is made of a transparent rigid body 10, and the pressure member for pressing the electrode plate against the porous spacers 12 is arranged on the top surface of the flexible electrode plate. In another way, the flexible electrode plate is constituted flexing partially toward the respective through holes of the porous spacers 12 so as to hold the dispersion system 7 in the porous spacers 12 under negative pressure. Consequently, the dispersion system 7 can securely be charged in the respective pores of the porous spacers 12 without leaving any residual empty hole and the dispersion system can easily and securely be injected in a short period.





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⑭発明の名称　電気泳動表示装置及びその製造法

⑳特　願　昭63-131242
㉒出　願　昭63(1988)5月28日

㉑発明者　尾城　達彦　茨城県稲敷郡茎崎町天宝喜757　日本メクトロン株式会社開茨城工場内
㉑発明者　多田隈　昭　茨城県稲敷郡茎崎町天宝喜757　日本メクトロン株式会社南茨城工場内
㉑発明者　森　高志　茨城県稲敷郡茎崎町天宝喜757　日本メクトロン株式会社開茨城工場内
㉑出願人　日本メクトロン株式会社　東京都港区芝大門1丁目12番15号
㉔代理人　弁理士　鍛田　秋光

最終頁に続く

明　細　書

1．発明の名称

電気泳動表示装置及びその製造法

2．特許請求の範囲

(1) 少なくとも一方が透明質に構成された一組の対向配置した電極板間に多孔性スペーサを介して電気泳動粒子を分散させた分散系を不連続相に分割して封入する構造の電気泳動表示装置に於いて、上記一方の電極板を上記多孔性スペーサに密着可能な可撓性に構成し、且つ上記他方の電極板を透明質な剛体で構成すると共に、該可撓性電極板の上面にこの電極板を上記多孔性スペーサに押付ける為の加圧部材を配装すべく構成したことを特徴とする電気泳動表示装置。

(2) 少なくとも一方が透明質に構成された一組の対向配置した電極板間に多孔性スペーサを介して電気泳動粒子を分散させた分散系を不連続相に分割して封入する構造の電気泳動表示装置に於いて、上記一方の電極板を上記多孔性スペーサに密着可能な可撓性に構成し、且つ上記他方の電極板を透明質な剛体で構成する一方、上記多孔性スペーサに於ける分散系を自圧に保持させるように上記可撓性電極板を該多孔性スペーサの各透孔側に部分的に撓ませるべく構成したことを特徴とする電気泳動表示装置。

(3) 前記可撓性電極板の基材がフィルム部材であり、また、上記剛体電極板の基材が透明ガラス板である請求項(1)又は(2)に記載の電気泳動表示装置。

(4) 前記加圧部材が、気体、液体又は弾性固体の少なくとも一つで構成された請求項(1)に記載の電気泳動表示装置。

(5) 前記加圧部材の上面に押圧板を備える請求項(4)に記載の電気泳動表示装置。

(6) 前記多孔性スペーサが光硬化性樹脂又はフィルムである前記請求項のいずれかに記載の電気泳動表示装置。

(7) 前記多孔性スペーサを光硬化性樹脂としての感光性ドライフィルムで構成した請求項(6)に記載の電気泳動表示装置。

(8) 前記多孔性スペーサはその端部周域に上記可撓性電極板との接着固定部を具備する前記請求項のいずれかに記載の電気泳動表示装置．

(9) フィルム部材及び透明ガラス板の各一方面に所要の電極パターンをそれぞれ形成した可撓性電極板と透明な剛体電極板とを用意し，該剛体電極板の電極パターン側に配設した多孔性スペーサに電気泳動粒子を分散させた分散系を通則に供給した後，上記可撓性電極板をその電極パターンが上記剛体電極板の電極パターンと対面するように上記多孔性スペーサ上に配設し，次に上記可撓性電極板の上面に加圧部材を配置して該可撓性電極板を上記多孔性スペーサに密着させて余分な分散系を押し出すことにより上記多孔性スペーサの各孔に上記分散系を封入することを特徴とする電気泳動表示装置の製造法．

(10) フィルム部材及び透明ガラス板の各一方面に所要の電極パターンをそれぞれ形成した可撓性電極板と透明な剛体電極板とを用意し，該剛体電極板の電極パターン側に配設した多孔性スペーサに電気泳動粒子を分散させた分散系を通則に供給した後，上記可撓性電極板をその電極パターンが上記剛体電極板の電極パターンと対面するように上記多孔性スペーサ上に配設し，次に上記可撓性電極板の上面側に加圧力を作用させてこの可撓性電極板を上記多孔性スペーサに密着させて余分な分散系を押し出しながら，この可撓性電極板を該多孔性スペーサの各孔に対して部分的に接着させることにより，上記多孔性スペーサの各孔に上記分散系を負圧状態に封入保持することを特徴とする電気泳動表示装置の製造法．

(11) 前記加圧部材又は加圧力付与手段に，気体，液体又は弾性固体の少なくとも一つを使用する請求項(9)又は(10)に記載の電気泳動表示装置の製造法．

(12) 前記加圧部材又は加圧力付与手段と共に押圧板を使用し，これらの押圧板及び上記加圧部材をそのまま配設するか又は除去する請求項(11)に記載の電気泳動表示装置の製造法．

(13) 前記多孔性スペーサが光硬化性樹脂又はフィルム部材で上記剛体電極板側に予め形成された請求項(9)～(12)のいずれかに記載の電気泳動表示装置の製造法．

(14) 前記光硬化性樹脂として感光性ドライフィルムを使用し，フォトリソグラフィ手段で上記多孔性スペーサを形成した請求項(13)に記載の電気泳動表示装置の製造法．

(15) 前記多孔性スペーサの端部周域に上記可撓性電極板に対する接着固定部を形成するようにした請求項(9)～(14)のいずれかに記載の電気泳動表示装置の製造法．

(16) 前記加圧部材による上記可撓性電極板に対する押圧状態又は該可撓性電極板の前記撓みによる分散系の負圧状態で，上記多孔性スペーサの接着固定部に該当する端部周域で上記加圧部材と共に又は該加圧部材なしにそれらの外周部に接着剤を設けて該多孔性スペーサ及び前記電極板間を固定接合する請求項(15)に記載の電気泳動表示装置の製造法．

3 発明の詳細な説明

「産業上の利用分野」

本発明は電気泳動粒子を利用した表示装置に於いて，一方の電極板に樹脂製フィルム等からなる可撓性基材を用いることにより，分散系を小区間に不連続的に分割するための多孔性スペーサの各孔に分散系を確実に封入できるように構成した電気泳動表示装置及びその製造法に関する．

「従来の技術」

電気泳動粒子を利用したこの種の電気泳動表示装置は，第4図に示すように，対向面に各々酸化インジウム・スズ等の透明導電膜からなる透明導電部材を使用して所要の表示用電極パターン2，4を各別に形成した二枚の透明ガラス板1，3を設け，液体分散媒に電気泳動粒子6を分散させた分散系7をその対向面間隙間に封入すべくスペーサ兼用の封止部材5を外周部位に配設した構造を有する．このような表示装置は，電極パターン2，4に表示駆動用電圧を印加して電気泳動

粒子6を電極パターン2、4に吸着・離反させ得るように分散系7に電界を作用させて電気泳動粒子6の分布状態を変えることにより分散系7の光学的特性に変化を与えて所望の表示動作を行なわせるものである。

分散系7の封入態様として上記の如く端部に設けた封止部材5によって連続相状に構成する場合には、両電極パターン2、4間の間隙むら等による電界強度の不均一に起因して電気泳動粒子6が電極パターン面と平行方向な移動を起こして電気泳動粒子の濃度分布に偏りを生じ、その為にこの電気泳動表示装置を長時間繰返し使用すると電気泳動粒子の濃度が場所的に不均一になったり表示むらを発生するという問題がある。

そこで、上記の如き不都合を解消する手段として、第5図の如く、多数の透孔を備えた多孔性スペーサ8を用いて各透孔に分散系を封入し、以って分散系7を小区間に不連続相に分割するような構造も特開昭49－32038号、特開昭59－34518号又は特開昭59－171930号各公報等で公知である。

「課題を解決するための手段」

本発明は、多孔性スペーサを使用した分散系分割型の電気泳動表示装置に於いて、多孔性スペーサの各孔に分散系を容易確実に注入させることの可能な電気泳動表示装置並びにその製造法を提供するものである。

この目的を達成する為に本発明に係る電気泳動表示装置では、少なくとも一方が透明質に構成された一組の対向配置した電極板間に多孔性スペーサを介して電気泳動粒子を分散させた分散系を不連続相に分割して封入する構造の電気泳動表示装置に於いて、上記一方の電極板を上記多孔性スペーサに密着可能な可撓性に構成し、且つ上記他方の電極板を透明質な剛体で構成すると共に、該可撓性電極板の上面にこの電極板を上記多孔性スペーサに押付ける為の加圧部材を配装すべく構成するか、又は、上記多孔性スペーサに於ける分散系を負圧に保持させるように上記可撓性電極板を該多孔性スペーサの各透孔側に部分的に撓ませるべく構成したものである。

「発明が解決しようとする課題」

しかし、多孔性スペーサを用いて分散系を小区間に不連続相に分割する分散系分割型の電気泳動表示装置の上記公知例の場合に於いて、両電極板に各々基板フィルムを使用する場合には、フィルムの変形等によって多孔性スペーサと電極板間に隙間を生じ易いので、電気泳動粒子の偏在を発生させる虞がある。また、双方ともガラス板の基材で両電極板を構成する場合には、ガラス板の平面性と多孔性スペーサの厚みの分布の関係により、多孔性スペーサと電極板間に隙間を残す部分を発生し、斯かる構造の場合でも電気泳動粒子の偏在を防止することは容易ではない。

更に、両電極板と介装多孔性スペーサとを予め接着したセル構造のものでは、多孔性スペーサの各孔に分散系を一様に注入することは非常に困難である等、分散系注入処理に伴なう製造上の欠点が種々存在する他、分散系注入の不完全な部分が発生して表示欠陥となる虞が多分にあり、信頼性の高い表示装置を得る上での解決課題は多い。

多孔性スペーサはこの構造に適合な如く感光性ドライフィルム等の光硬化性樹脂又はその他のフィルム部材で構成し、また、その端部周縁には少なくとも上記可撓性電極板との密着を容易化する接着固定部を一体に設けるように構成するのが好ましい。

斯かる電気泳動表示装置は、フィルム部材及び透明ガラス板の各一方面に所要の電極パターンをそれぞれ形成した可撓性電極板と透明な剛体電極板とを用意し、該剛体電極板の電極パターン側に配装した多孔性スペーサに電気泳動粒子を分散させた分散系を過剰に供給した後、上記可撓性電極板をその電極パターンが上記剛体電極板の電極パターンと対面するように上記多孔性スペーサ上に配装し、次に上記可撓性電極板の上面に加圧部材を配設して該可撓性電極板を上記多孔性スペーサに密着させて余分な分散系を押し出すことにより上記多孔性スペーサの各孔に上記分散系を封入する製造法を採用できる。

また、この電気泳動表示装置の他の製造法とし

ては、フィルム部材及び透明ガラス板の各一方面に所要の電極パターンをそれぞれ形成した可撓性電極板と透明な剛体電極板とを用意し、該剛体電極板の電極パターン側に配設した多孔性スペーサに電気泳動粒子を分散させた分散系を過剰に供給した後、上記可撓性電極板をその電極パターンが上記剛体電極板の電極パターンと対面するように上記多孔性スペーサ上に配装し、次に上記可撓性電極板の上面側に加圧力を作用させてこの可撓性電極板を上記多孔性スペーサに密着させて余分な分散系を押し出しながら、この可撓性電極板を該多孔性スペーサの各孔に対して部分的に嵌ませることにより、上記多孔性スペーサの各孔に上記分散系を負圧状態に封入保持するような手法も採用可能である。

このような電気泳動表示装置を製造する際に、多孔性スペーサは、感光性ドライフィルム等の光硬化性樹脂又はその他のフィルム部材を使用して上記剛体電極板に予め一体に形成することも可能である。

「実　施　例」

以下、図示の実施例を参照しながら本発明を更に詳述する。第１図に於いて、１０は透明な剛体電極板を構成するための基材としての透明なガラス板であってその上面には酸化インジウム・スズ等の透明導電材料を用いて所要の電極パターン１１を適宜形成してある。この剛体電極板の上面には分散系を小区間に分割して封入するための多孔性スペーサ１２を配装してあるが、斯かる多孔性スペーサ１２は、光硬化性樹脂の印刷手段又は予め所要の透孔を多数穿設したフィルム部材を用いて該電極板の電極パターン１１を形成した側に一体的に設けるか、或いは光硬化性樹脂として感光性ドライフィルムのフォトリソグラフィ手段などで適宜構成できる。多孔性スペーサ１２は、第２図に示す如く、分散系の分割封入のための多数の透孔１２Ｂに加えて、該スペーサ１２の端部周域には後述の可撓性電極板との関連に於いて、透孔のない斜線で示す接着固定部１２Ａを形成しておくのが好適である。このような多孔性スペーサ１２の上面には上記電極パターン１１と対向する面に他の対向電極パターン１４を形成したフィルム基材１３からなる可撓性電極板を配置すべく構成されている。１５は加圧部材であって、これは多孔性スペーサ１２の各孔１２Ｂに過剰に供給した分散系７を可撓性電極板の上面から押圧することにより、その余分な分散系を押し出して多孔性スペーサ１２の各孔１２Ｂに空孔のない分散系７の完全な封入を行なわせるためのものであり、斯かる加圧部材には、気体、液体又は弾性固体の少なくとも一つを適宜使用できる。図示の加圧部材１５は、ゴム質又はスポンジ等の弾性固体を用いた例を示す。１６は加圧部材１５の上面部に配設した押圧保持板であり、また、１７は構成部材間をそれらの端部で固定接合するための接着剤である。

このような分散系分割型の電気泳動表示装置を製作するには、透明ガラス板１０及び透明電極パターン１１からなる剛体電極板の該電極パターン１１上に第２図に示すような多孔性スペーサ１２を形成した後、表示目的に最適な如く適宜な液体分散媒に酸化チタン等の電気泳動粒子を分散させて予め調製した分散系７を多孔性スペーサ１２に所要量以上に過剰に供給してこの多孔性スペーサ１２を該分散系７で完全に覆っておく。次いで、上記可撓性電極板をその電極パターン１４が剛体電極板の電極パターン１１と対面するように多孔性スペーサ１２に重ね合わせた後、可撓性電極板の上面側に加圧部材１５と押圧保持板１６とを各々配設した上、押圧保持板１６に弾圧力を加えて加圧部材１５を可撓性電極板に十分に押し付けて多孔性スペーサ１２と密着させる。これにより、多孔性スペーサ１２に対し上記で過剰に供給された余分な分散系は該スペーサ１２の各孔１２Ｂから押し出され、また、加圧部材１５の介在によって可撓性電極板は上記スペーサ１２の各孔１２Ｂに部分的に侵入して撓んだ状態となって、多孔性スペーサ１２の各透孔１２Ｂに対し残存空孔のない分散系７の完全な封入処理を容易迅速に施すことができる。

そこで、多孔性スペーサ１２の端部周域に形成

した接着固定部１２Ａに該当する構成部材の端部をクランプした状態で加圧押圧力を解除し、その端部周域に第１図の如く接着剤１７を設けて構成部材の相互間を固定接合することにより、多孔性スペーサ１２による分散系７の小区間に分割した不連続相状の分散系分割型の電気泳動表示装置を簡便に構成できる。

接着剤１７による部材間の上記相互接合処理に於いて、図の如く、剛体電極板の外端部を可撓性電極板及び多孔性スペーサ１２や加圧部材１５及び押圧保持板１６のそれより適宜大きく形成し、その段差部に接着剤１７を付着させるように構成することも部材間の接合処理に際して好適なものとなる。

上記構造に於いて、多孔性スペーサ１２に対する分散系７の上記押し出し封入処理後、上記の如く多孔性スペーサ１２の端部周域に形成した接着固定部１２Ａに該当する可撓性電極板の端部をクランプした状態で加圧押圧力を解除し、次いで、加圧部材１５及び押圧保持板１６の双方を取り去り、多孔性スペーサ１２及び可撓性電極板の端部周域に第３図の如く接着剤１７を設けて構成部材の相互間を固定接合すると、同図の如く、可撓性電極板の捲み部分の復帰により、封入分散系７を自圧状態に保持した他の構造による分散系分割型の電気泳動表示装置を製作することが出来る。

この第３図の電気泳動表示装置を用る手法に於いて、分散系押し出しの為の加圧力付与手段は、上記加圧部材１５及び押圧保持板１６の使用に限らず、その他の任意な加圧力付与手段を適宜採用できる。

上記第１図及び第３図の構造による分散系分割型の電気泳動表示装置に於いては、透明ガラス板１０を備える剛体電極板側を電気泳動表示用として使用することが出来る。

上記の電気泳動表示装置に於いて、分散系７を不連続相に小区画に分割するための多孔性スペーサ１２は上記構成手段の他、シリコンゴム、フッ素系ゴム等のゴム部材で適宜構成できる絶縁性材料の使用、又はトランスポリイソプレンゴム、ノボルネン系ポリマー若しくはエチレンプロピレン系合成ゴム等の形状記憶機能を具備する各種のポリマーの採用も可能である。更に、斯かる多孔性スペーサ１２は、形状記憶ポリマーを用いてスクリーン印刷又はスプレー手段等で多数の透孔を設け得るように一方の電極パターン１１又は１４上に直接的に形成するか、若しくはシート状に成形したシリコンゴム等を用いて打抜き又はドリル加工等の手段で所要の透孔を多数形成した後、熱プレス等の手段によりその厚さを隣電極板の間隙以下となるように適宜成形することもできる。多孔性スペーサ１２の各透孔１２Ｂの形状は、角状又はスリット状等の他、円状や矩形状又は多角形状等任意に設定することができ、その配列も規則的又は不規則的に設けることができる。斯かる多孔性スペーサ１２の厚さは、シリコンゴム又は形状記憶ポリマーなど使用すべき部材の弾性率、分散媒の組成や隣電極板間の間隙等を考慮することにより適宜選定できるが、一般的は２０μｍ～１ｍｍ程度に定めることができる。

分散系７に使用する電気泳動粒子は、周知の各種のコロイド粒子のほか、種々の有機・無機顔料、染料、金属粉、ガラス若しくは樹脂等の微粉末などを適宜使用できる。また、分散系７の分散媒としては、水、アルコール類、炭化水素、ハロゲン化炭化水素等の他、天然又は合成の各種の油などを任意使用できる。また、分散系７には必要に応じ、電解質、界面活性剤、金属石けんの他、樹脂、ゴム、油、ワニス、コンパウンド等の粒子からなる荷電制御剤に加えて、分散剤、潤滑剤、安定化剤等を適宜添加できる。更に、電気泳動粒子の荷電を正又は負に統一したり、ゼータ電位を高める手段や分散を均一安定化する手段のほか、電気泳動粒子の電極パターン１１、１４に対する吸着性や分散媒の粘度等の調整も適宜行なうことが可能である。

一実施例に於いて、フィルム基材及び透明ガラス板の各一方面に酸化インジウム・スズを用いてそれぞれ所要の透明な電極パターンを形成した両電極板を用意し、その一方の剛体電極板の電極パ

クーン形成側に光硬化性レジストフィルムを配設して第２図の如き格子のメッシュ状にパターンエングして多孔性スペーサを形成した。

一方，分散系用液体分散媒としてヘキシルベンゼン 100 cc を用意し，これにオイルブルーＢＡからなる着色の染料 1 gとシルバンＳ８３からなる界面活性剤 0.5 gとを溶かし，この溶媒に電気泳動粒子として酸化チタン５ｇを分散させて分散系を調製した。この分散系を空気が残らないように多孔性スペーサに適剤に注いでこのスペーサを完全に覆った。次に，可撓性電極板を第１図及び第３図のようにこの多孔性スペーサ上に配置し，この可撓性電極板の表面側に加圧部材と押圧保持板とを配置するか，又は，配置することなく，その可撓性電極板側に加圧押圧力を作用させることにより，可撓性電極板を多孔性スペーサの各孔に部分的に侵入して埋む程度に十分に密着させながら余分な分散系を押し出して多孔性スペーサの各透孔に分散系を完全に封入した後，該スペーサと密着した可撓性電極板の端部周域をクランプし，又は、加圧部材と押圧保持板と共に上記の如くクランプした．最後に．この部分に於いて両電極板及びスペーサを含む構成部材の端部周をエポキシ系接着剤で接着固定し、第１図及び第３図の如き分散系分割型の電気泳動表示装置を得た．

この表示装置の電極板間に直流７０Ｖの電圧を反復的に印加してスイッチング試験を行なったところ、百万回のスイッチング経過後でも電気泳動粒子の偏りは認められず．コントラストの良好な表示動作を得た．

「発明の効果」

以上のとおり、本発明に係る電気泳動表示装置は．多孔性スペーサを使用して分散系を小区間に不連続相に分割するようにした電気泳動表示装置に於いて、加圧部材を配設するか又は該加圧部材なしに加圧押圧力の作用により、一方の電極板を多孔性スペーサに対して密着させ得るように可撓性に構成したので、この可撓性電極板を配設する前に先ず分散系を多孔性スペーサに対して一括的に適剤に供給し，次いで．可撓性電極板を多孔性スペーサ上に配置した状態で可撓性電極板に加圧押圧力を付与して多孔性スペーサの各孔に一部が侵入して埋む態様で可撓性電極板を多孔性スペーサに十分に密着させながら余分な分散系を押し出すことにより、残存空孔を生じさせることなく．多孔性スペーサの各孔に分散系を確実に封入可能となり、これにより．分散系の注入処理を能率よく短時間に容易確実に行なえる．

また，分散系押し出し封入処理の為の加圧押圧力を解除した後．構成部材の端部周域を固定接合した構造では、分割封入分散系を負圧状態に保持できる．

多孔性スペーサは、ガラス板等の基材を用いて透明質に構成した剛体電極板の電極パターン形成側に，感光性ドライフィルム等の光硬化性樹脂又はその他のフィルム部材を用いて一体状に形成でき．その際．剛体電極板を固定板の如く機能させて行なう上記適剤分散系の押し出し封入処理及び可撓性電極板との密着封止に有利な如く、多孔性スペーサの端部周域には接着固定部を形成し、この部分を活用して構成部材間の一時的な固定と最終的な接着固定処理を容易に行なえる．

従って．多孔性スペーサの各透孔に分散系を確実に封入して表示欠陥の生ずる恐のないコントラストの良好な信頼性の優れた高特性の分散系分割型電気泳動表示装置を提供できる．

４．図面の簡単な説明

第１図は本発明の一実施例に従って透明剛体電極板と可撓性電極板とを具備するように構成した電気泳動表示装置に於いて、可撓性電極板の上面に分散系押し出し封入用加圧部材を配設した構造の分散系分割型の電気泳動表示装置の概念的な断面構成図．

第２図は本発明で採用した透明剛体電極板の電極パターン形成側に設けるべき多孔性スペーサの概念的な部分拡大平面構成図、

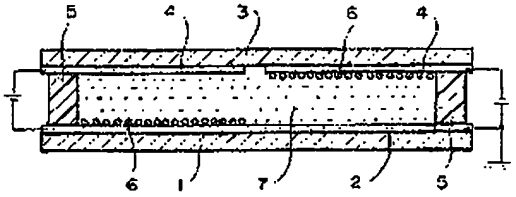
第３図は本発明の他の実施例により分散系を負圧状態に保持した構造の同様な断面構成図、

第４図は多孔性スペーサを使用しない従来の分散系連続相型の電気泳動表示装置の概念的な

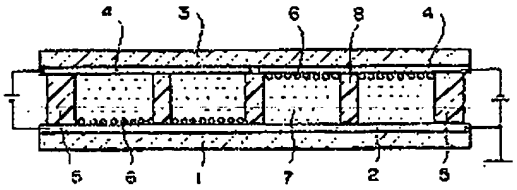
要部断面構成図、そして、

第５図は多孔性スペーサを備えた従来の分散系分割型電気泳動表示装置を分散系注入に伴なう問題点と共に示す概念的な要部断面構成図である。

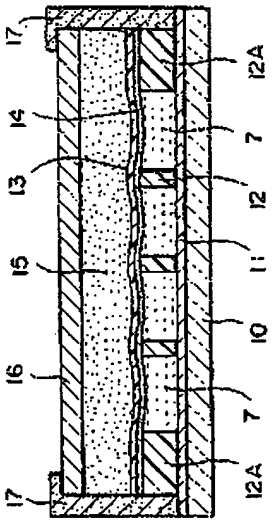
１，３：透明ガラス板
２，４：電極パターン
５：端部スペーサ
６：電気泳動粒子
７：表示分散系
８：多孔性のスペーサ
１０：透明ガラス板
１１：電極パターン
１２：多孔性のスペーサ
１２Ａ：接着固定部
１２Ｂ：多数の透孔
１３：フィルム基材
１４：電極パターン
１５：加圧部材
１６：押圧保持板
１７：固定用接着剤



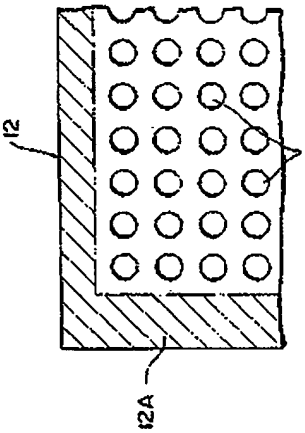
第４図



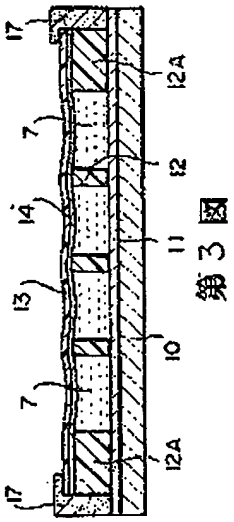
第５図



第１図



第２図



第３図

第1頁の続き

⑫発明者 赤塚 孝寿 茨城県稲敷郡茎崎町天宝喜757 日本メクトロン株式会社南茨城工場内

⑫発明者 外山 二郎 茨城県稲敷郡茎崎町天宝喜757 日本メクトロン株式会社南茨城工場内

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(72) Inventor: Tatsuhiko Oshiro (c/o Nippon Mektron, Ltd., Minami Ibaraki Plant, 757 Amaboki, Kukizaki-cho, Inashiki-gun, Ibaraki-ken)

(72) Inventor: Akira Tadakuma (same address as above)

(72) Inventor: Takashi Mori (same address as above)

(71) Applicant: Nippon Mektron, Ltd. (12–15 Shibadaimon 1-chome, Minato-ku, Tokyo)

(74) Agent: Akimitsu Kamata, Patent Attorney

(Continued on last page)

SPECIFICATION

1. Title of the Invention

Electrophoretic Display Device and Manufacturing Method Thereof

2. Claims

(1) An electrophoretic display device, wherein a disperse system containing dispersed electrophoretic particles is divided into a discontinuous phase and is sealed by means of a porous spacer between oppositely disposed electrode plates of which at least one is made transparent, said electrophoretic display device characterized in that the transparent electrode plate is made flexible to be able to adhere closely to the porous spacer; the other electrode plate is configured from a transparent rigid body; and a pressure member designed to press this electrode plate against the porous spacer is mounted on the upper surface of the flexible electrode plate.

(2) An electrophoretic display device, wherein a disperse system containing dispersed electrophoretic particles is divided into a discontinuous phase and is sealed by means of a porous spacer between oppositely disposed electrode plates of which at least one is made transparent, said electrophoretic display device characterized in that said one electrode plate is made flexible to be able to adhere closely to the porous spacer; the other electrode plate is configured from a transparent rigid body; and the flexible electrode plate is rendered partially flexible toward the through-holes of the porous spacer such that the disperse system in the porous spacer is kept under negative pressure.

(3) The electrophoretic display device according to claim 1 or 2, wherein the substrate for the flexible electrode plate is a film member, and the substrate for the rigid electrode plate is a transparent glass plate.

(4) The electrophoretic display device according to claim 1, wherein the pressure member is composed of a least one material selected from gases, liquids, and elastic solids.

(5) The electrophoretic display device according to claim 4, wherein a press-down plate is mounted on the upper surface of the pressure member.

(6) The electrophoretic display device according to any of the preceding claims, wherein the porous spacer is a photocuring resin or film.

(7) The electrophoretic display device according to claim 6, wherein the porous spacer is composed of a photosensitive dry film as the photocuring resin.

(8) The electrophoretic display device according to any of the preceding claims, wherein the porous spacer is provided with an adhesive fixing part for forming a bond with the two electrode plates in the peripheral area along the edges thereof.

(9) A method for manufacturing an electrophoretic display device, characterized in that a flexible electrode plate and a transparent rigid electrode plate are prepared by forming the desired electrode pattern on one side of each of a film member and a transparent glass plate; a disperse system containing dispersed electrophoretic particles is fed in excess to a porous spacer mounted on the side of the rigid electrode plate with the electrode pattern; the flexible electrode plate is then mounted on the porous spacer such that the electrode pattern thereof faces the electrode pattern of the rigid electrode plate; and the disperse system is subsequently sealed in the holes of the porous spacer by placing a pressure member on the upper surface of the flexible

electrode plate, causing the flexible electrode plate to closely adhere to the porous spacer, and squeezing out the excess disperse system.

(10) A method for manufacturing an electrophoretic display device, characterized in that a flexible electrode plate and a transparent rigid electrode plate are prepared by forming the desired electrode pattern on one side of each of a film member and a transparent glass plate; a disperse system containing dispersed electrophoretic particles is fed in excess to a porous spacer mounted on the side of the rigid electrode plate with the electrode pattern; the flexible electrode plate is then mounted on the porous spacer such that the electrode pattern thereof faces the electrode pattern of the rigid electrode plate; and the disperse system is subsequently sealed and kept under negative pressure in the holes of the porous spacer by applying pressure to the upper surface of the flexible electrode plate, causing the flexible electrode plate to closely adhere to the porous spacer, and allowing the flexible electrode plate to partially bend into the holes of the porous spacer while squeezing out the excess disperse system.

(11) The method for manufacturing an electrophoretic display device according to claim 9 or 10, wherein a least one material selected from gases, liquids, and elastic solid is used for the pressure member or the pressure-applying means.

(12) The method for manufacturing an electrophoretic display device according to claim 11, wherein a press-down plate is used together with the pressure member or pressure-applying means, and the press-down plate and pressure member are directly mounted or removed.

(13) The method for manufacturing an electrophoretic display device according to any of claims 9 to 12, wherein the porous spacer is formed in advance from a photocuring resin or film member on the side with the rigid electrode plate.

(14) The method for manufacturing an electrophoretic display device according to claim 13, wherein a photosensitive dry film is used as the photocuring resin to form the porous spacer by photolithographic means.

(15) The method for manufacturing an electrophoretic display device according to any of claims 9 to 14, wherein an adhesive fixing part for forming a bond with the flexible electrode plate is formed in the peripheral area along the edges of the porous spacer.

(16) The method for manufacturing an electrophoretic display device according to claim 15, wherein an adhesive is applied to the external peripheral portion thereof, and the

porous spacer and the two electrode plates are fixedly bonded together with or without the use of the pressure member in the peripheral area along the edges that correspond to the adhesive fixing part of the porous spacer in a state in which the flexible electrode plate is pressed down with the pressure member, or in a state in which the disperse system is kept under negative pressure by the bending of the flexible electrode plate.

3. Detailed Description of the Invention

(Field of Industrial Utilization)

The present invention relates to an electrophoretic display device with electrophoretic particles, wherein this display device is configured such that a disperse system is securely sealed in the pores of a porous spacer for separating the disperse system into a finely fragmented discontinuous phase by using a flexible substrate composed of a resin film or the like as one of the electrode plates; and to a method for manufacturing this display.

(Prior Art)

An electrophoretic display device with electrophoretic particles is configured such that two transparent glass plates 1 and 3 separately provided with the desired display electrode patterns 2 and 4, respectively, by the use of tin/indium oxide or another appropriate transparent electroconductive member are disposed on opposite sides, and a sealing member 5 that doubles as a spacer and allows a disperse system 7 obtained by dispersing electrophoretic particles 6 in a liquid dispersion medium to be sealed in the space between the plates is disposed along the external periphery, as shown in Fig. 4. In such a display device, the optical characteristics of the disperse system 7 are caused to vary and the desired display action can be induced by applying a display drive voltage to the electrode patterns 2 and 4 and causing an electric field to act on the disperse system 7 such that the electrophoretic particles 6 are adsorbed on, or desorbed from, the electrode patterns 2 and 4.

Adopting an arrangement in which a continuous phase is formed by the sealing member 5 in the end section in the above described manner to ensure that the disperse system 7 is sealed is disadvantageous in that any nonuniformity in the electric field strength resulting from defects such as variations in the gap between the two electrode patterns 2 and 4 causes the

electrophoretic particles 6 to move parallel to the surfaces of the electrode patterns, creates nonuniformities in the concentration distribution of the electrophoretic particle, and, as a result, causes the concentration of the electrophoretic particles to become nonuniform when the electrophoretic display device is repeatedly used for a long time.

In view of this, known structures in which a porous spacer 8 provided with large numbers of through-holes is used to seal the disperse system in the through-holes, and hence to divide the disperse system 7 into a finely fragmented discontinuous phase in the manner shown in Fig. 5, have been proposed as a means for overcoming the above-described shortcomings in JP (Kokai) 49-32038, 59-34518, 59-171930, and the like.

(Problems to Be Solved by the Invention)

When, however, substrate films are used for both electrode plates in the above-described example of an electrophoretic display device with a divided disperse system in which the disperse system is divided into a finely fragmented discontinuous phase by using a porous spacer, there is danger that the electrophoretic particles may become unevenly distributed because gaps tend to form between the porous spacer and the electrode plates due to film deformation or the like. In addition, configuring both electrode plates from glass plate substrates causes areas with gaps to form between the electrode plates and the porous spacer because of the relation between the flatness of the glass plates and the distribution of the porous spacer thickness, making it difficult to prevent the electrophoretic particle from being unevenly distributed in this structure as well.

Furthermore, it is extremely difficult to uniformly inject a disperse system into the pores of a porous spacer in a device with a cell structure in which the two electrode plates and the interposed porous spacer are bonded in advance. Numerous other structural difficulties are encountered during the injection treatment of the disperse system; the disperse system often ends up being injected only incompletely in some areas, often bringing about display defects; and numerous other problems are encountered in terms of obtaining a highly reliable display device.

(Means Used to Solve the Above-Mentioned Problems)

An object of the present invention is to provide an electrophoretic display device that has a divided disperse system and is based on the use of a porous spacer, wherein this electrophoretic display device allows the disperse system to be injected into the holes of the porous spacer easily and securely; and to provide a method for manufacturing this device.

Developed in order to attain the stated object, the electrophoretic display device according to the present invention is one in which a disperse system containing dispersed electrophoretic particles is divided into a discontinuous phase and is sealed by means of a porous spacer between oppositely disposed electrode plates of which at least one is made transparent, wherein this electrophoretic display device is such that the transparent electrode plate is made flexible to be able to adhere closely to the porous spacer; the other electrode plate is configured from a transparent rigid body; and a pressure member designed to press this electrode plate against the porous spacer is mounted on the upper surface of the flexible electrode plate, or the flexible electrode plate is rendered partially flexible toward the through-holes of the porous spacer such that the disperse system in the porous spacer is kept under negative pressure.

According to a preferred embodiment, the porous spacer is composed of a photocuring resin such as a photosensitive dry film, or by using another film member considered to be optimal for the spacer structure, and the adhesive fixing part is formed integrally with the peripheral area along the edges thereof to make it easier to create a bond at least with the flexible electrode plate.

The electrophoretic display device can be manufactured by a method in which a flexible electrode plate and a transparent rigid electrode plate are prepared by forming the desired electrode pattern on one side of each of a film member and a transparent glass plate; a disperse system containing dispersed electrophoretic particles is fed in excess to a porous spacer mounted on the side of the rigid electrode plate with the electrode pattern; the flexible electrode plate is then mounted on the porous spacer such that the electrode pattern thereof faces the electrode pattern of the rigid electrode plate; and the disperse system is subsequently sealed in the holes of the porous spacer by placing a pressure member on the upper surface of the flexible electrode

plate, causing the flexible electrode plate to closely adhere to the porous spacer, and squeezing out the excess disperse system.

According to another method for manufacturing the electrophoretic display device, it is possible to adopt a means whereby a flexible electrode plate and a transparent rigid electrode plate are prepared by forming the desired electrode pattern on one side of each of a film member and a transparent glass plate; a disperse system containing dispersed electrophoretic particles is fed in excess to a porous spacer mounted on the side of the rigid electrode plate with the electrode pattern; the flexible electrode plate is then mounted on the porous spacer such that the electrode pattern thereof faces the electrode pattern of the rigid electrode plate; and the disperse system is subsequently sealed and kept under negative pressure in the holes of the porous spacer by applying pressure to the upper surface of the flexible electrode plate, causing the flexible electrode plate to closely adhere to the porous spacer, and allowing the flexible electrode plate to partially bend into the holes of the porous spacer while squeezing out the excess disperse system.

The porous spacer may also be integrally preformed with the rigid electrode plate by using a photocuring resin such as a photosensitive dry film, or by using another film member during the manufacture of such an electrophoretic display device.

(Embodiments)

The present invention is described in further detail below with reference to illustrated embodiments. In Fig. 1, "10" is a transparent glass plate as a substrate for forming a transparent rigid electrode plate, and the desired electrode pattern 11 is formed thereon by using tin/indium oxide or another transparent electroconductive material. A porous spacer 12 for dividing and sealing the disperse system into small areas is mounted on the rigid electrode plate. The porous spacer 12 may be integrally formed on the side of the electrode plate with the electrode pattern 11 by a method that involves printing a photocuring resin, or by the use of a film member in which numerous required through-holes have been made in advance. It is also possible to employ an appropriate structure obtained, for example, by a photolithographic technique in which a photosensitive dry film is used for the photocuring resin. The porous spacer 12 has a large number of through-holes 12B for dividing and sealing the disperse system, and further has an adhesive fixing part 12A (shown by hatching) without through-holes in the area in which the

spacer is joined with the flexible electrode plates described hereinbelow, as shown in Fig. 2. In this structure, a flexible electrode plate composed of a film substrate 13 with a facing electrode pattern 14 is mounted on the upper surface of such a porous spacer 12 so that the pattern is disposed opposite the aforementioned electrode pattern 11. 15 is a pressure member with which the disperse system 7 fed in excess into the holes 12B of the porous spacer 12 is pressed down from the top surface of the flexible electrode plate to squeeze out the excess disperse system and to completely seal the disperse system 7 without any voids in the spaces inside the holes 12B of the porous spacer 12. At least one material selected from gases, liquids, and elastic solids can be appropriately used as the pressure member. In the example illustrated, the pressure member 15 is constructed using rubber, a sponge, or other elastic solid. 16 is a press-down plate provided on top of the pressure member 15, and 17 is an adhesive for fixedly bonding the structural members together along their edges.

To manufacture such an electrophoretic display device with a distributed disperse system, a porous spacer 12 such as the one shown in Fig. 2 is formed on the electrode pattern 11 of a rigid electrode plate comprising a transparent glass plate 10 and the transparent electrode pattern 11; titanium oxide particles or other electrophoretic particles are dispersed in a liquid dispersion medium suitable for display purposes; a disperse system 7 prepared in advance is fed in excess to the porous spacer 12 in an amount that is greater than necessary; and the porous spacer 12 is completely covered with the disperse system 7. The flexible electrode plate is subsequently superposed on the porous spacer 12 such that the electrode pattern 14 of the plate faces the electrode pattern 11 of the rigid electrode plate; the pressure member 15 and the press-down plate 16 are then placed on the flexible electrode plate; and elastic pressure is applied to the press-down plate 16 to cause the pressure member 15 to firmly press against the flexible electrode plate and to bond tightly with the porous spacer 12. The disperse system fed in excess into the porous spacer 12 in the above-described manner will thereby be squeezed out from the holes 12B of the spacer 12; the presence of the interposed pressure member 15 will cause the flexible electrode plate to partially enter and bend inside the holes 12B of the spacer 12; and a disperse system 7 free of any remaining voids will be sealed in the through-holes 12B of the porous spacer 12 as a result of an operation that can be conducted with ease and speed.

At this point, pressure is released while clamping is applied along the ends of the structural member that corresponds to the adhesive fixing part 12A formed in the peripheral area along the edges of the porous spacer 12; an adhesive 17 is supplied to the peripheral area along the edges in the manner shown in Fig. 1; and the structural members are fixedly bonded together to make it easy to obtain an electrophoretic display device with a divided disperse system in the form of a discontinuous phase in which the disperse system 7 is divided into small compartments by the porous spacer 12.

The members may also be appropriately bonded together with the aid of the adhesive 17 by adopting an arrangement in which the outer ends of the rigid electrode plate are made somewhat larger than those of the flexible electrode plate, porous spacer 12, pressure member 15, and press-down plate 16; and the adhesive 17 is applied to the resulting ledges, as shown in the drawing.

A differently configured electrophoretic display device with a divided disperse system in which the sealed disperse system 7 is kept under negative pressure can be fabricated by allowing the flexible portions of the flexible electrode plate to recover when the disperse system 7 is squeezed out and sealed in the porous spacer 12; pressure is released while clamping is applied to the end portions of the flexible electrode plate that corresponds to the adhesive fixing part 12A formed in the peripheral area along the edges of the porous spacer 12 in the above-described manner, the pressure member 15 and press-down plate 16 are then removed; and the adhesive 17 is applied in the manner shown in Fig. 3 to the peripheral area along the edges of the porous spacer 12 and the flexible electrode plate to fixedly bond the structural members together, as shown in the drawings.

The pressure-applying means for squeezing out the disperse system in the method for obtaining the electrophoretic display device in Fig. 3 is not limited to the use of the pressure member 15 and press-down plate 16, and any other pressure-applying means may be appropriately adopted.

In the electrophoretic display device with a divided disperse system configured as shown in Figs. 1 and 3, the side of the transparent glass plate 10 with the rigid electrode plate can be used for electrophoretic display purposes.

In addition to the above-described structural means, the following materials may also be used to form the porous spacer 12 designed to divide the disperse system 7 into a discontinuous phase in small compartments in the electrophoretic display device described above: expandable materials appropriately made with silicone rubber, fluororubber, and other rubber members, as well as transpolyisoprene rubber, no[r]bornene-based polymers, ethylene-propylene synthetic rubber, and other polymers with shape memory functions. Furthermore, the porous spacer 12 can be directly formed on the electrode pattern 11 or 14 from the aforementioned memory polymers such that numerous through-holes are fashioned by screen printing, spraying, or the like. Alternatively, the spacer may be appropriately molded by a technique in which numerous required through-holes are formed by punching or drilling silicone rubber or another material molded into a sheet, and the thickness of the sheet is then made equal to or less than the size of the gap between the two electrode plates by hot pressing or another means. The through-holes 12B of the porous spacer 12 may be shaped not only as slits or square holes, but also as circular holes, rectangular holes, polygonal holes, or other arbitrarily shaped holes, and may have a regular or irregular arrangement. The thickness of the porous spacer 12 may be appropriately selected with consideration for the recovery rate of the silicone rubber, shape-memory polymers, and other members being used, the composition of the dispersion medium, the gap between the two electrode plates, and the like, and is commonly set to about 20 μm to 1 mm.

The electrophoretic particles used for the disperse system 7 may be any of the various commonly known types of colloid particles, or any of a variety of microparticulate organic or inorganic pigments, dyes, metals, glass, resins, and the like. The dispersion medium of the disperse system 7 may be water, an alcohol, a hydrocarbon, a halogenated hydrocarbon, or the like, or any of the various natural or synthetic oils or the like. It is also possible to add the following ingredients to the disperse system 7 as needed: electrolytes, surfactants, metallic soaps, particulate charge-controlling agents (such as resins, rubber, oil, varnish, and compounds), dispersants, lubricants, stabilizers, and the like. Means may also be employed to increase the zeta potential, to endow the electrophoretic particles with the same type of charge (positive or negative), or to make the dispersion process uniformly stable. It is further possible to appropriately adjust the adsorption of the electrophoretic particles on the electrode patterns 11 and 14, the viscosity of the dispersion medium, or the like.

According to one embodiment, tin/indium oxide was used to prepare two electrode plates by forming the desired transparent electrode pattern on one side of each of a film substrate and a transparent glass plate, a photocuring resist film was placed over one of the rigid electrode plates on the side with the electrode pattern, and a mesh-like pattern whose structure is shown in Fig. 2 was formed, yielding a porous spacer.

Hexyl benzene (100 cc) was prepared as the liquid dispersion medium for the disperse system, 1 g of a navy blue dye composed of Oil Blue BA and 0.5 g of a surfactant composed of Sylvan S83 were dissolved therein, 5 g of titanium oxide was dispersed in the solvent as electrophoretic particles, and a disperse system was prepared. This disperse system was poured in excess into the porous spacer such that no air remained, and the spacer was completely covered. A flexible electrode plate was then placed over the porous spacer in the manner shown in Figs. 1 and 3, and a pressure member and a press-down plate were mounted on the surface of the flexible electrode plate. Alternatively, pressure could be applied to the flexible electrode plate without mounting the aforementioned pressure member or press-down plate. As a result, the excess disperse system was squeezed out and completely sealed in the through-holes of the porous spacer while the flexible electrode plate was tightly bonded to the spacer to the extent that the flexible plate partially entered and bent inside the holes of the porous spacer. The peripheral area along the edges of the flexible electrode plate thus bonded to the spacer was clamped down, or the pressure member and the press-down plate were both clamped down. Finally, the end portions of the structural members that included the two electrode plates and the spacer in this section were bonded and fixed together with the aid of an epoxy adhesive, yielding an electrophoretic display device with a divided disperse system such as the one shown in Figs. 1 and 3.

A DC voltage of 70 V was repeatedly applied between the electrode plates of the display device to perform a switching test, but electrophoretic particles remained uniformly distributed even after a million switching cycles, and a highly contrast display operation could be performed.

(Effect of the Invention)

As described above, the electrophoretic display device pertaining to the present invention is one in which a porous spacer is used to divide the disperse system into a discontinuous phase in small compartments, wherein one of the electrode plates is endowed with flexibility so as to be caused to adhere closely to the porous spacer by the mounting of a pressure member or by the application of pressure without the use of such a pressure member. The disperse system is therefore first fed in excess as a single batch to the porous spacer before the flexible electrode plate is mounted, pressure is subsequently applied to the flexible electrode plate while this plate is mounted on the porous spacer, and the excess disperse system is squeezed out while the flexible electrode plate is firmly bonded to the porous spacer in a state in which the place partially enters and bends in the holes of the porous spacer, making it possible to securely seal the disperse system in the holes of the porous spacer without allowing any voids to remain, and hence to inject the disperse system efficiently, securely, rapidly, and easily.

In addition, the divided and sealed disperse system can be kept under negative pressure in a structure in which the peripheral area along the edges of the structural members is fixedly bonded following removal of the pressure designed to squeeze out and seal in the disperse system.

The porous spacer can be integrally formed using a photosensitive dry film or other photocuring resin or film member on that side of a rigid transparent electrode plate obtained using a glass plate or other substrate on which an electrode pattern is formed. In the process, a bonding and fixing section is formed in the peripheral area along the edges of the porous spacer to function as a fixing plate for the rigid electrode plate, to allow the excess disperse system to be squeezed out and sealed, and to create a tight seal with the flexible electrode plate. This section can be used to make it easier to temporarily fix the structural members together and to perform the final bonding and fixing.

It is therefore possible to provide an electrophoretic display device with a divided disperse system that has high contrast, enhanced reliability, and excellent characteristics. In this device, the disperse system is securely sealed in the through-holes of the porous spacer, and display defects never occur.

4. Brief Description of the Drawings

Fig. 1 is a schematic cross-sectional diagram of an electrophoretic display device configured such that a transparent rigid electrode plate and a flexible electrode plate are provided in accordance with an embodiment of the present invention, which is an electrophoretic display device with a divided disperse system wherein a pressure member for squeezing out and sealing in the disperse system is mounted on the top surface of the flexible electrode plate;

Fig. 2 is a schematic, partially enlarged plan view of the porous spacer provided to that side of the transparent rigid electrode plate adopted in the present invention on which an electrode pattern is formed;

Fig. 3 is a cross-sectional diagram of the same structure in which the disperse system is kept under negative pressure in accordance with another embodiment of the present invention;

Fig. 4 is a schematic cutaway view of a conventional electrophoretic display device with a disperse system in the form of a continuous phase obtained without the use of a porous spacer; and

Fig. 5 is a schematic cutaway view depicting a conventional electrophoretic display device with a divided disperse system that has a porous spacer to illustrate the problems that accompany the injection of the disperse system.

1, 3: transparent glass plates
2, 4: electrode patterns
5: edge spacer
6: electrophoretic particle
7: display disperse system
8: porous spacer
10: transparent glass plate
11: electrode pattern
12: porous spacer
12A: adhesive fixing part
12B: numerous through-holes

13: film substrate

14: electrode pattern

15: pressure member

16: press-down plate

17: adhesive for fixing

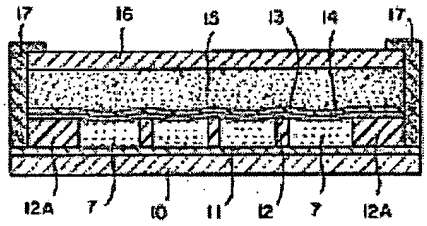

Fig. 1

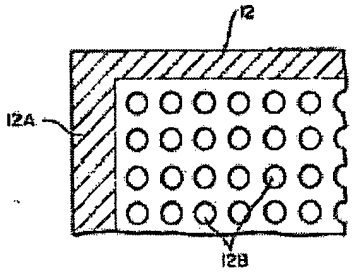

Fig. 2

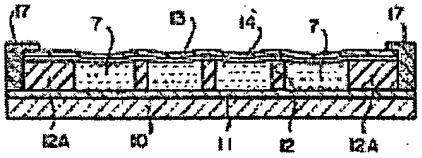

Fig. 3

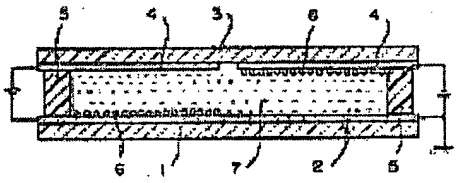

Fig. 4

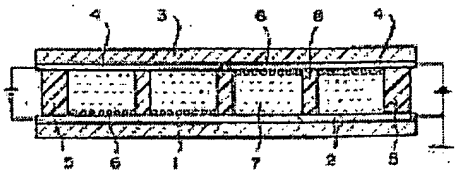

Fig. 5

(Continued from first page)

(72) Inventor: Takatoshi Akatsuka (c/o Nippon Mektron, Ltd., Minami Ibaraki Plant, 757 Amaboki, Kukizaki-cho, Inashiki-gun, Ibaraki-ken)
(72) Inventor: Jiro Toyama (same address as above)